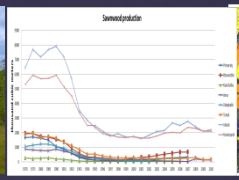
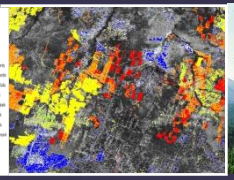
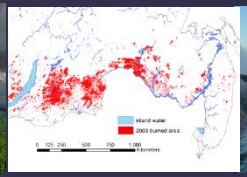
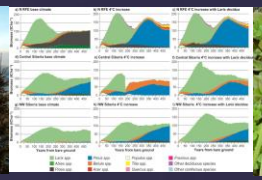









LCLUC Synthesis: Forested Land-Cover and Land-Use Change in the Far East of Northern Eurasia Under the Combined Drivers Of Climate and Socio-Economic Transformation

Multi-Institution Synthesis Team

- **Kathleen Bergen, Dan Brown, Josh Newell, Stephanie Hitztaler:** *University of Michigan*
- **Tatiana Loboda, Guoqing Sun:** *University of Maryland*
- **Hank Shugart, Jacqueline Shuman:** *University of Virginia*
- **Olga Krankina:** *Oregon State University*
- **Yuri Blam:** *Russian Academy of Sciences, Siberian Branch*

Outline

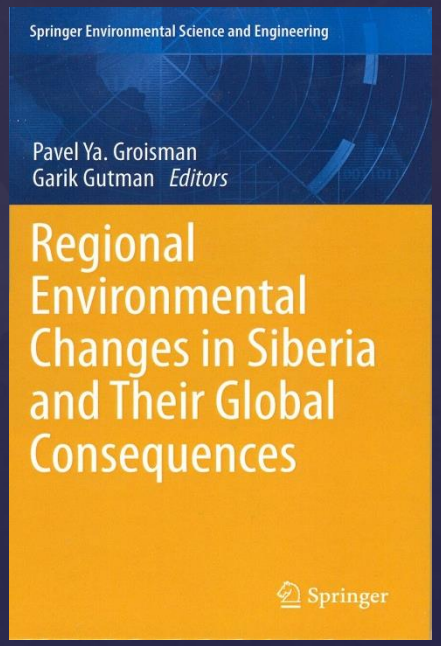
Past research and synthesis of past work for NASA Siberia book

Leads to….

New NASA LCLUC integrated synthesis project

Human Dimensions of Environmental Change chapter in NEESPI Siberia Book

Approach: 'a posteriori' synthesis of relevant social-science literature and of completed remote sensing LCLUC case studies illustrating main environmental change themes



Bergen, K. M., S. Hitztaler, V. Kharuk, O. N. Krankina, T. Loboda, T. T. Zhao, H. H. Shugart, and G. Sun (2012), Human Dimensions of Environmental Change in Siberia, Chapter 7 in *Regional Environmental Changes in Siberia and Their Global Consequences* edited by G. Gutman and P. Groisman, Kluwer Academic Publishers, Dordrecht.

Synthesis Region

Soviet Era 1922-1991

Demographics

- Large influxes of population through migration
- Growth of large urban centers

Land-Use Trends

- Conversion of steppe and southern taiga to industrial agriculture
- Expansion of mining, oil, gas sectors
- Harnessing of hydropower to supply industrialization
- The extension of railways

Institutions and Resource Management

- The beginning & height of industrial forestry

Post-Soviet Era Starting 1991-

Demographics

- Population loss in Siberia
- Deep economic hardship
- Transformation of people's livelihoods and their relationship to natural resources

Land-Use Trends

- Production from large industrial enterprises (esp. forestry) were brought nearly to a halt
- Collective agriculture partially dissolved
- Extractive industries least impacted

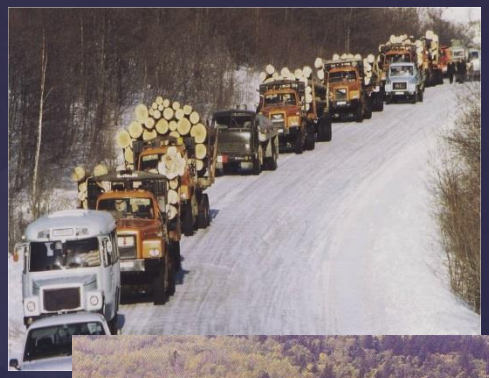
Institutions and Resource Management

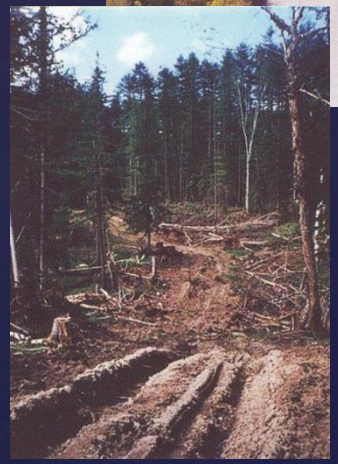
- Forestry decentralization and liberalization
- Unwittingly fostered the emergence of local oligarchies and illegal logging operations.

Synthesis Remote Sensing Case Study Sites Illustrate these LCLUC Themes

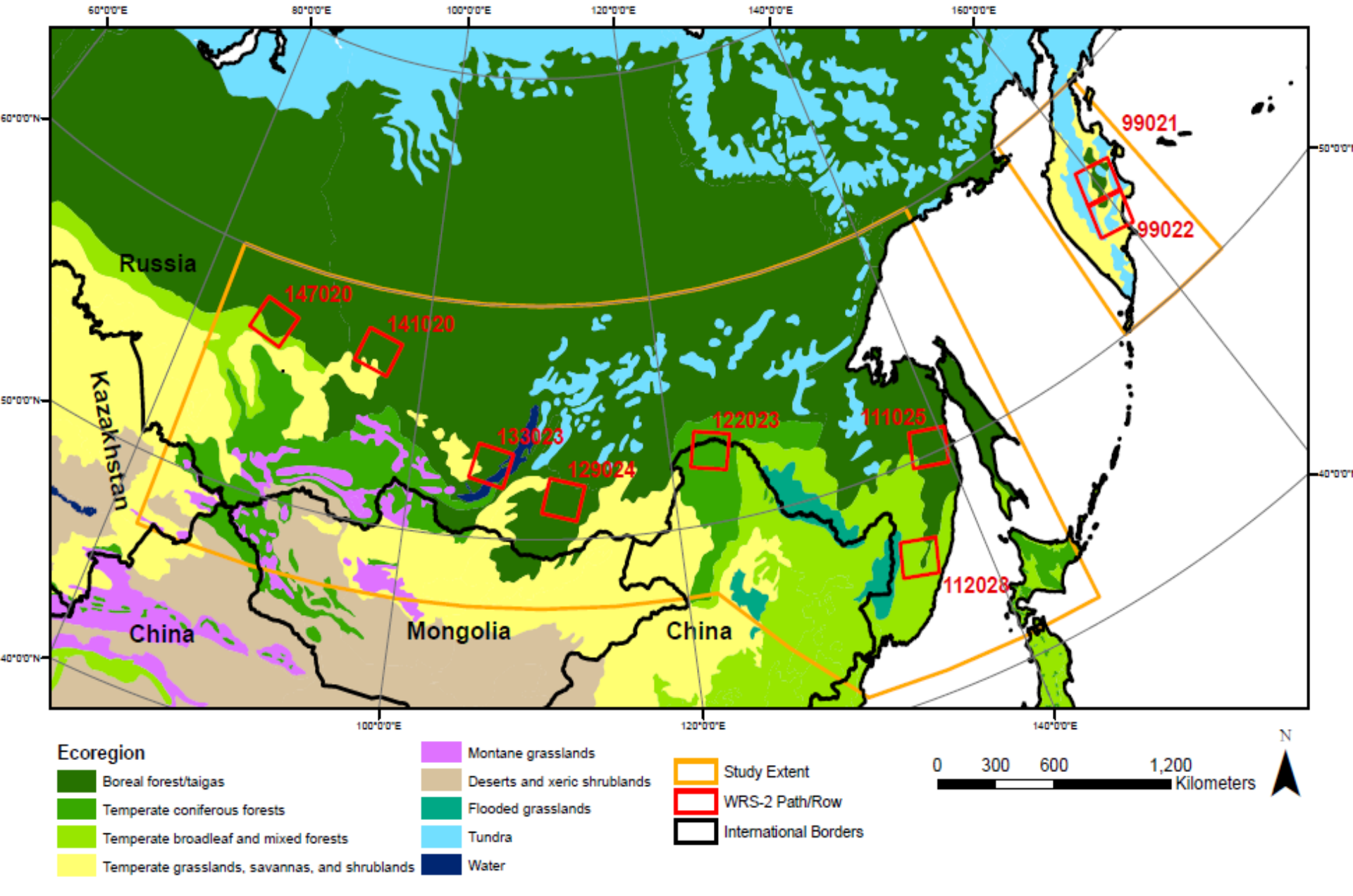
Some Observations Leading to Focus on the Northern Eurasian Far East:

- Overall increasing 'transnationalism' especially between Russia and Asia
- Oil/Gas activities shifting from West Siberia to East Siberia and the Far East
- Logging and timber in Siberia/Far East shifting to "external" exports with China & Japan biggest importers
- Region of some greatest predicted influences of climate change
- Lack of integrated synthesis to date
- Opportunities for new kinds of synthesis





New Synthesis Primary Study Area



Russian Wood Products Exports to China 2008

Map by J.P. Newell; spatial datasets from ESRI and World Resources Institute. Russian-Chinese export data from M-Info Consulting Company, 2009.

Research Question and Goal

- **Synthesis Research Question:** How have human-driven disturbances related to use of forest resources, combined with natural and other disturbances (fire, insects, agriculture), created the landscapes of the region over the past 35 years? How might they change in the future?

- **Goal:** Be able to quantify and attribute changes in land-use and land-cover due to climatic variability and due to changing anthropogenic socio-economic drivers in this large region. Build on and extend existing diverse research into synthesis in an approach that integrates remote sensing, socio-economic data & models.

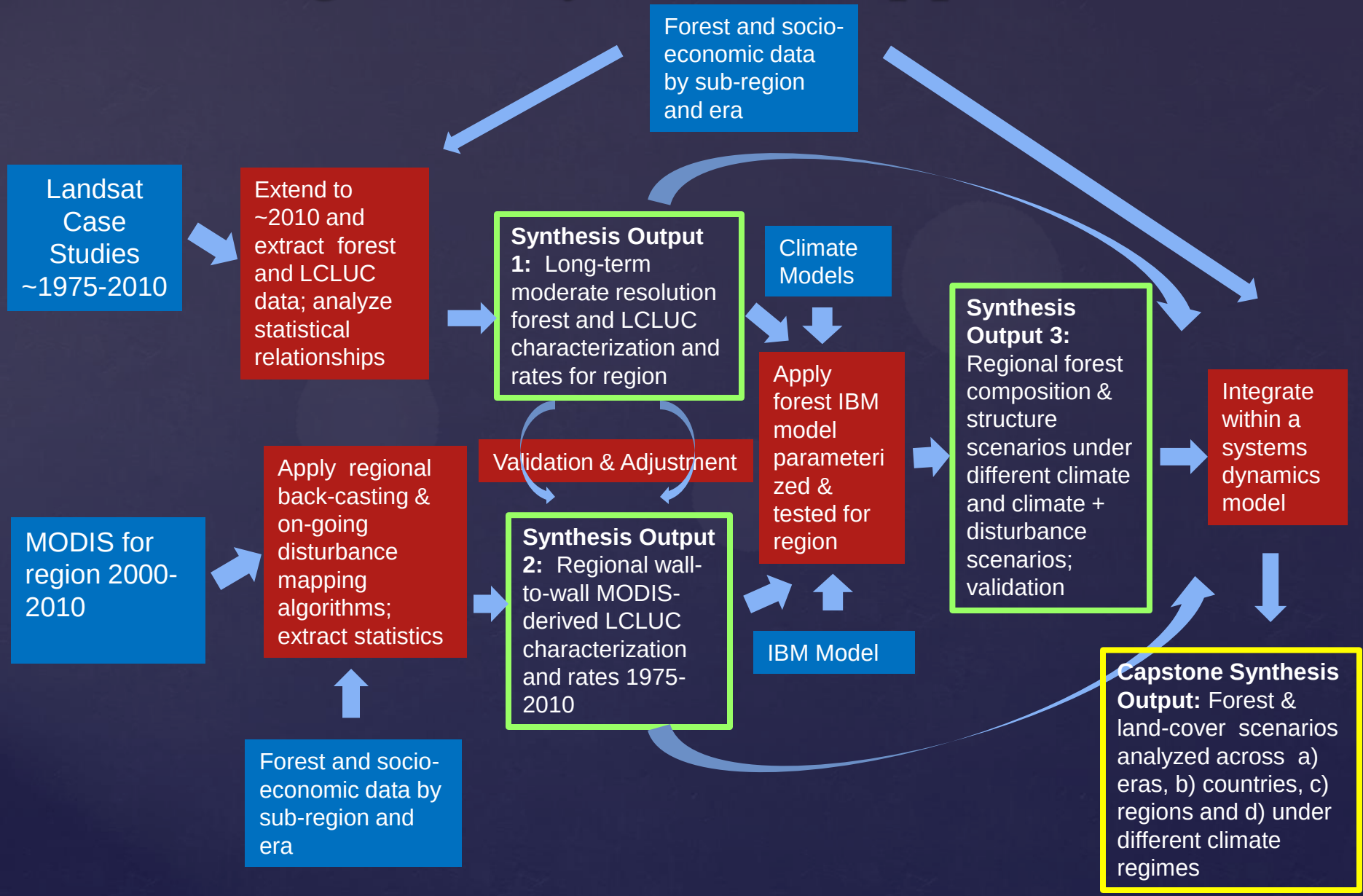
Three Characteristics of this LCLUC Synthesis Project

- 'A Priori' Integrative Approach: explicitly designed to integrate remote sensing, socio-economic data and several types of models (forest, climate, systems) to answer research question/s

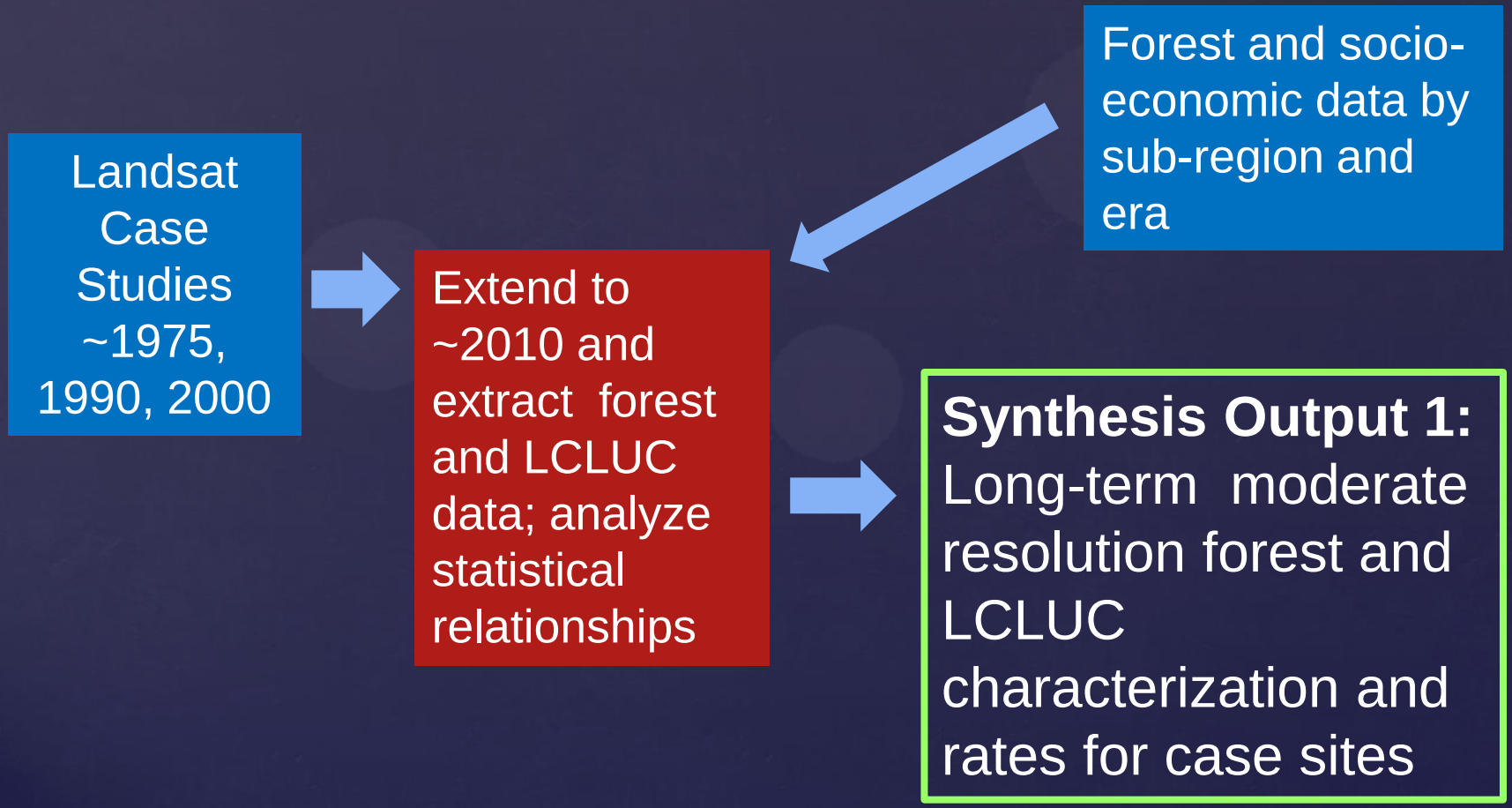
- Scaled Approach: Combines both Landsat-scale case study sites plus wall-to-wall MODIS over a large regional extent in East Siberia/Russian Far East

- Broader Context: focus on East Siberia/Russian Far East
- AND incorporation of external contexts

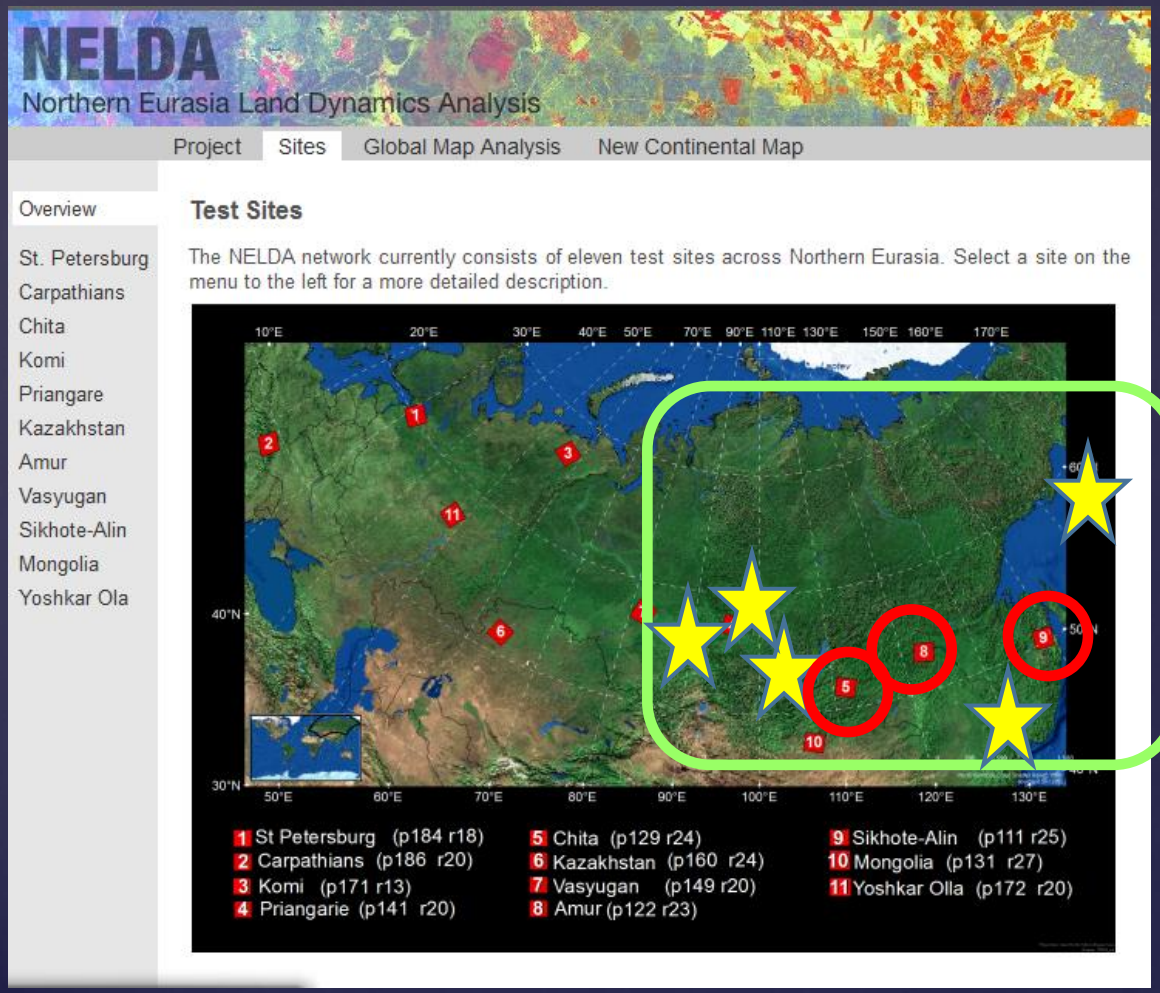
Integrated Synthesis Approach



Synthesis Output 1: Long-term LCLUC from Multiple Landsat Case Study Sites

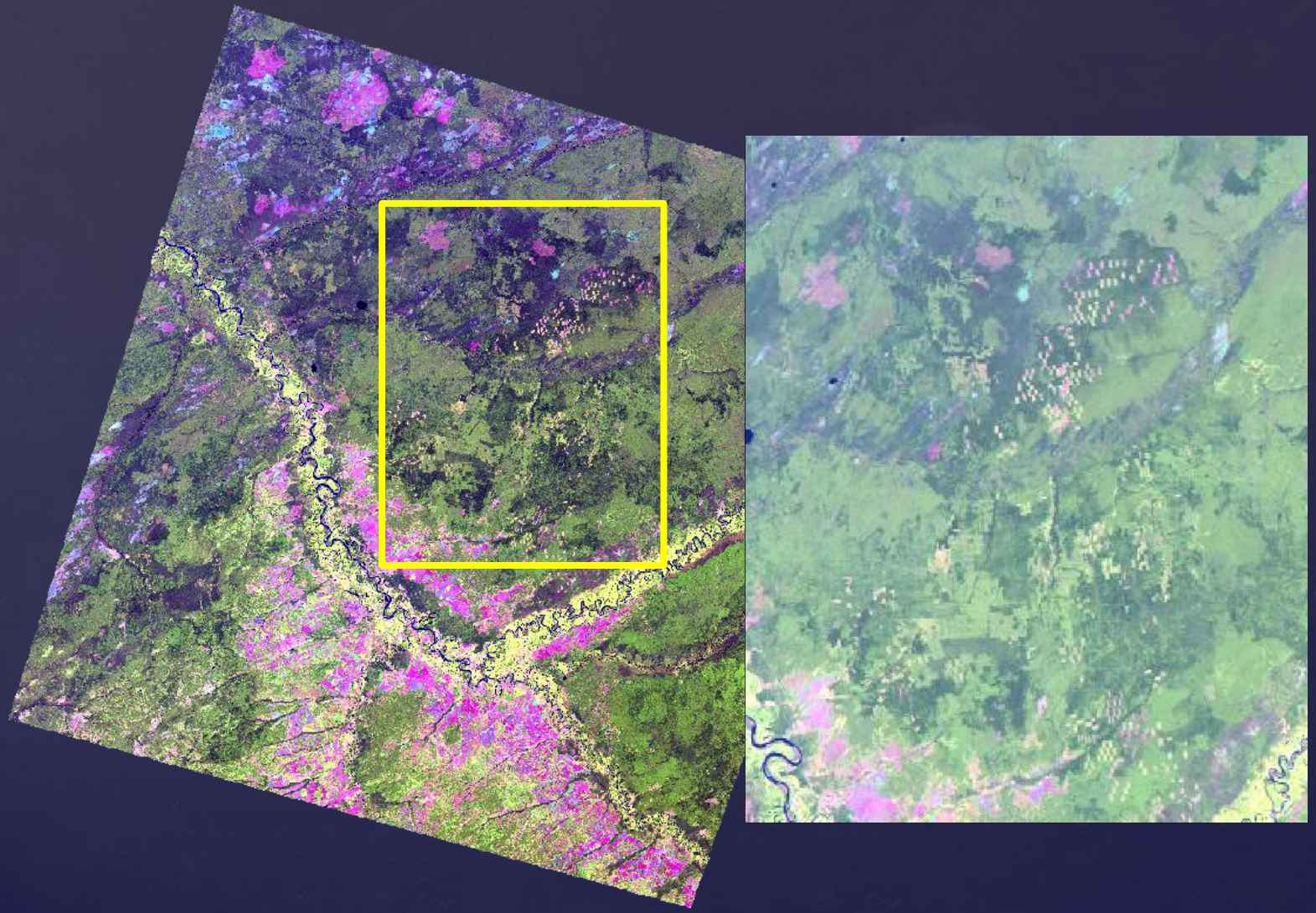


Landsat Case Study Sites



- Existing Siberia/RFE NELDA Sites: Chita, Amur, Sikhote-Alin
- Add U. Mich. Case Sites: Tomsk, Krasnoyarsk, Irkutsk, Primorsky, Kamchatka

Landscape change continues…a Landsat case study site in 2010



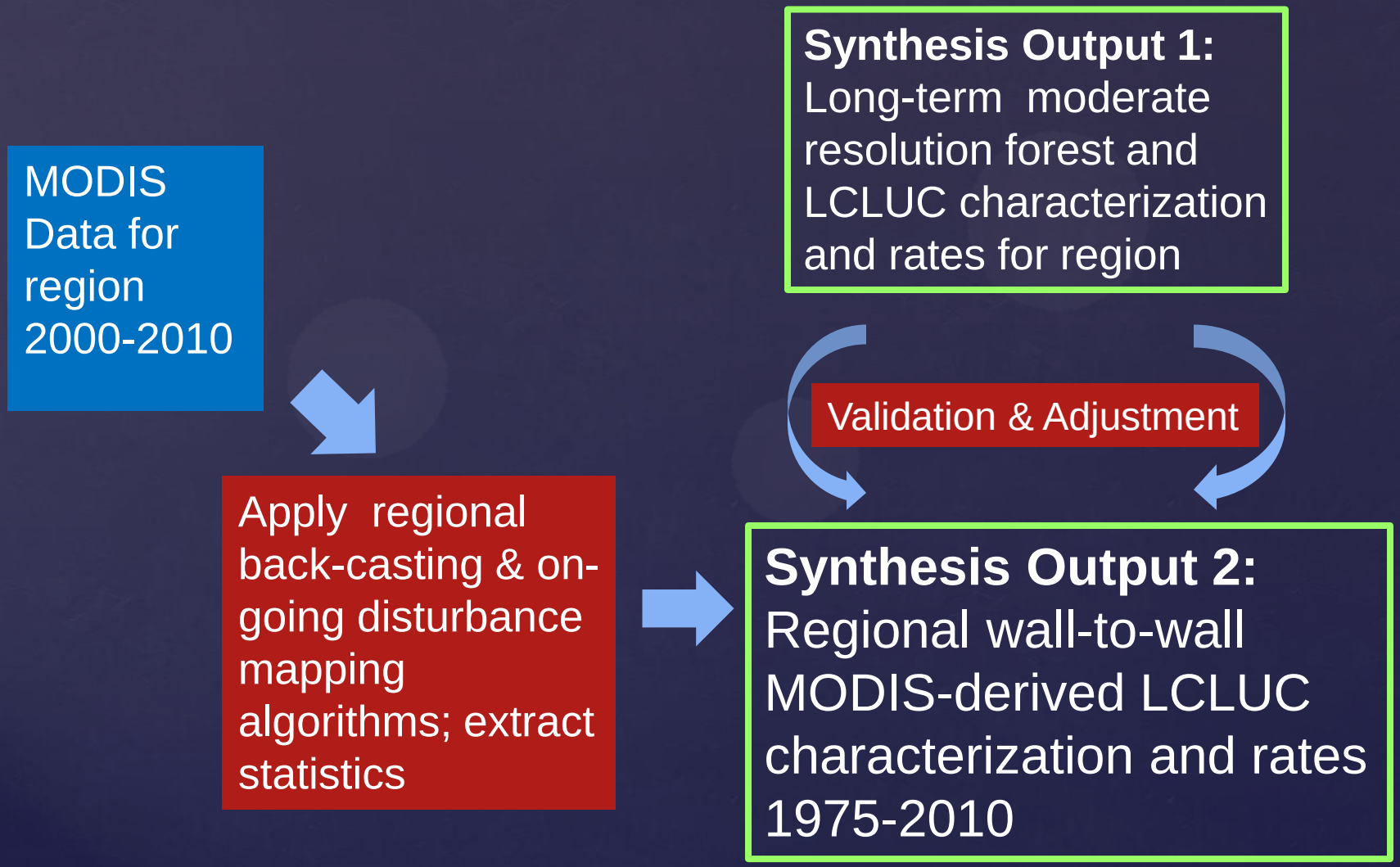
Synthesis Challenges

Merging two different classification schemes to integrate for synthesis

Data availability and quality for 2003-2010

- Future synthesis projects may benefit from “Landsat-8”

Synthesis Output 2: Long-Term Regional Disturbance Patterns from MODIS

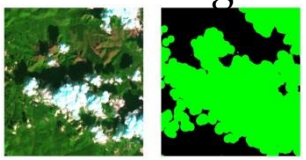


Objective 2: Reconstructing Forest Disturbances

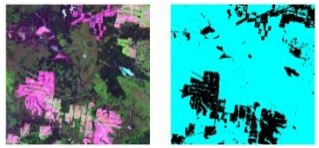
Randomized sample of Landsat stacks

LEDAPS-based Landsat TM/ETM+ surface reflectance

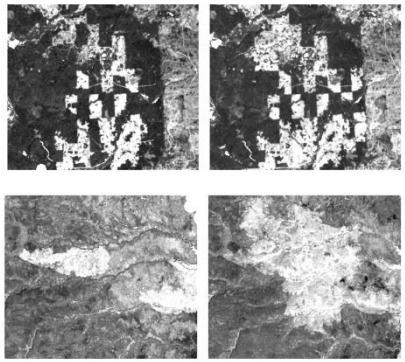
Cloud/shadow/water masking



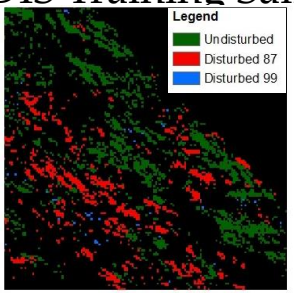
Mature forest masking



Disturbance Index



MODIS Training Sample



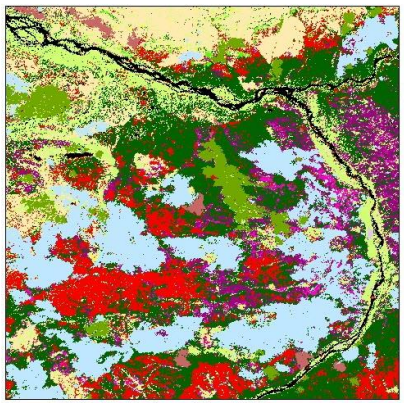
MODIS data sets:
MCD43A4
Nadir BRDF adjusted reflectance
MOD/MYD11A2
Land Surface Temperature

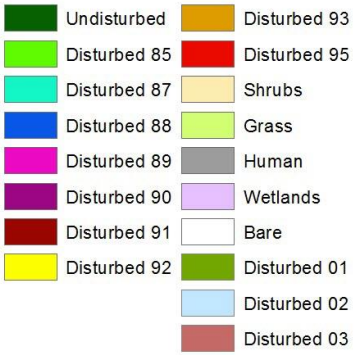
MODIS-based metrics :
yearly max, min, mean of Jun, Jul, Aug for surface reflectance Bands 1-6, NDVI, NBR, daytime & nighttime temperature)

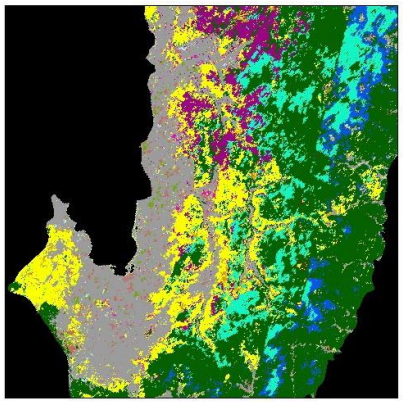
Decision-tree classifier

Past disturbance map

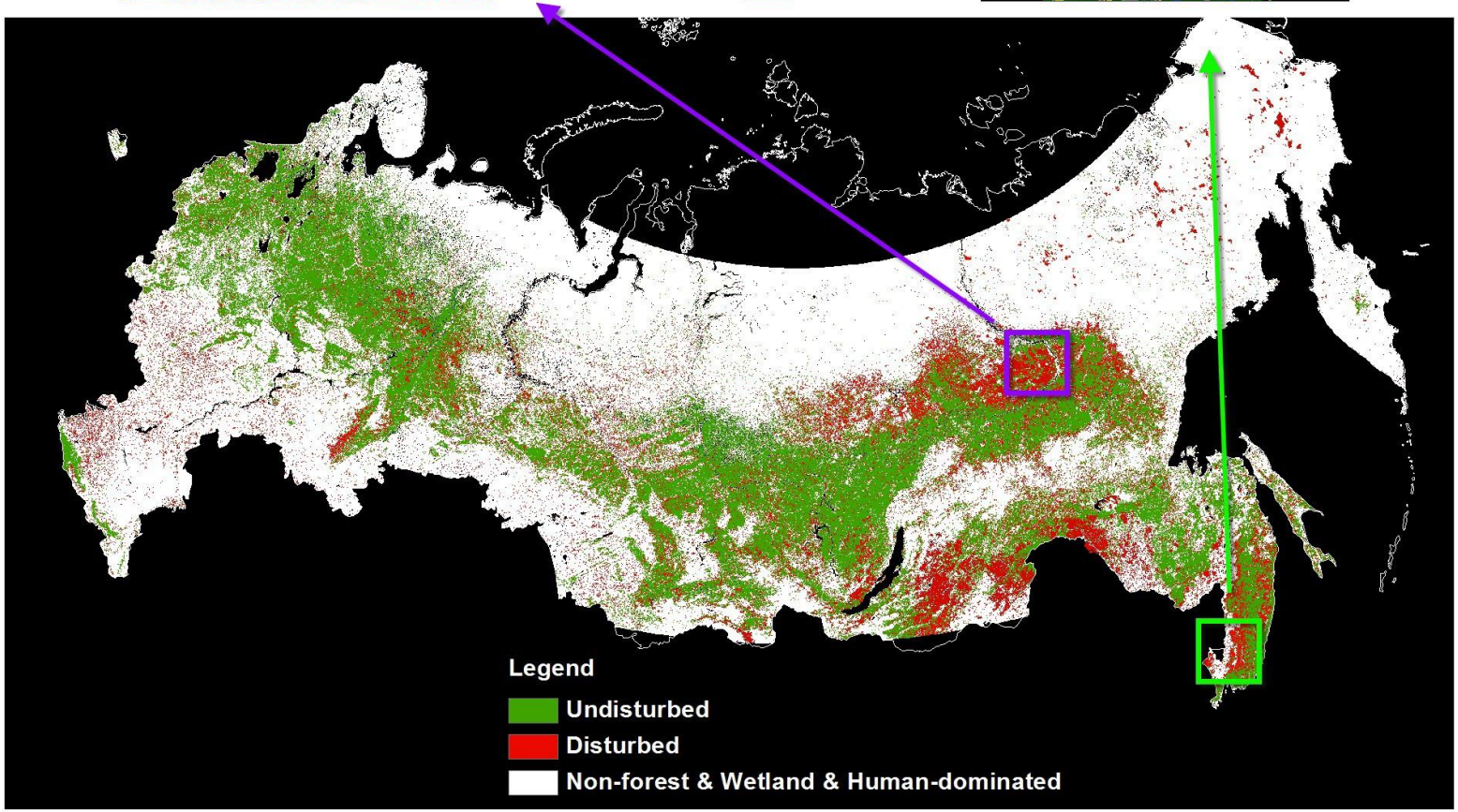
Past Forest Disturbance map (Beta)



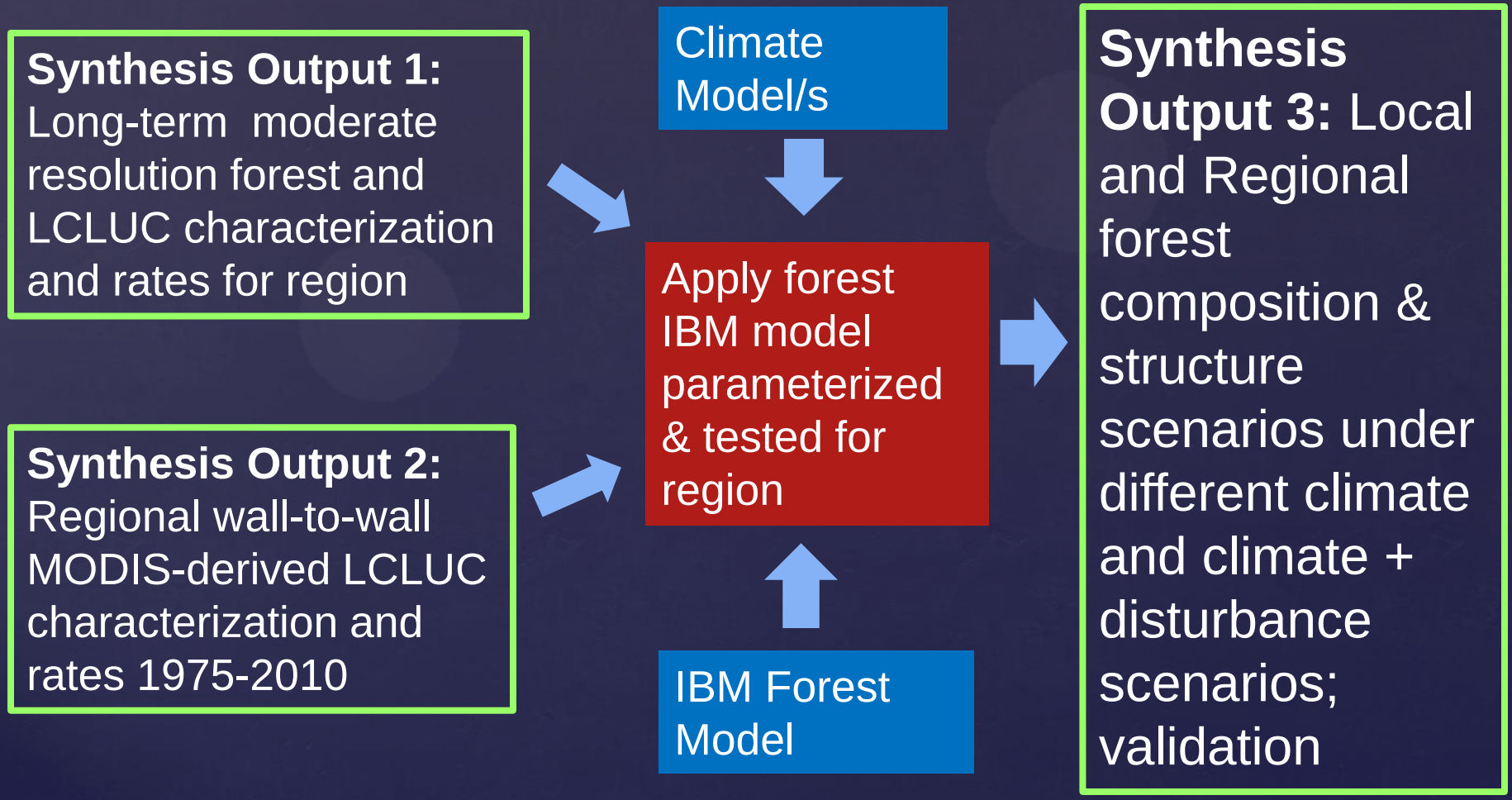




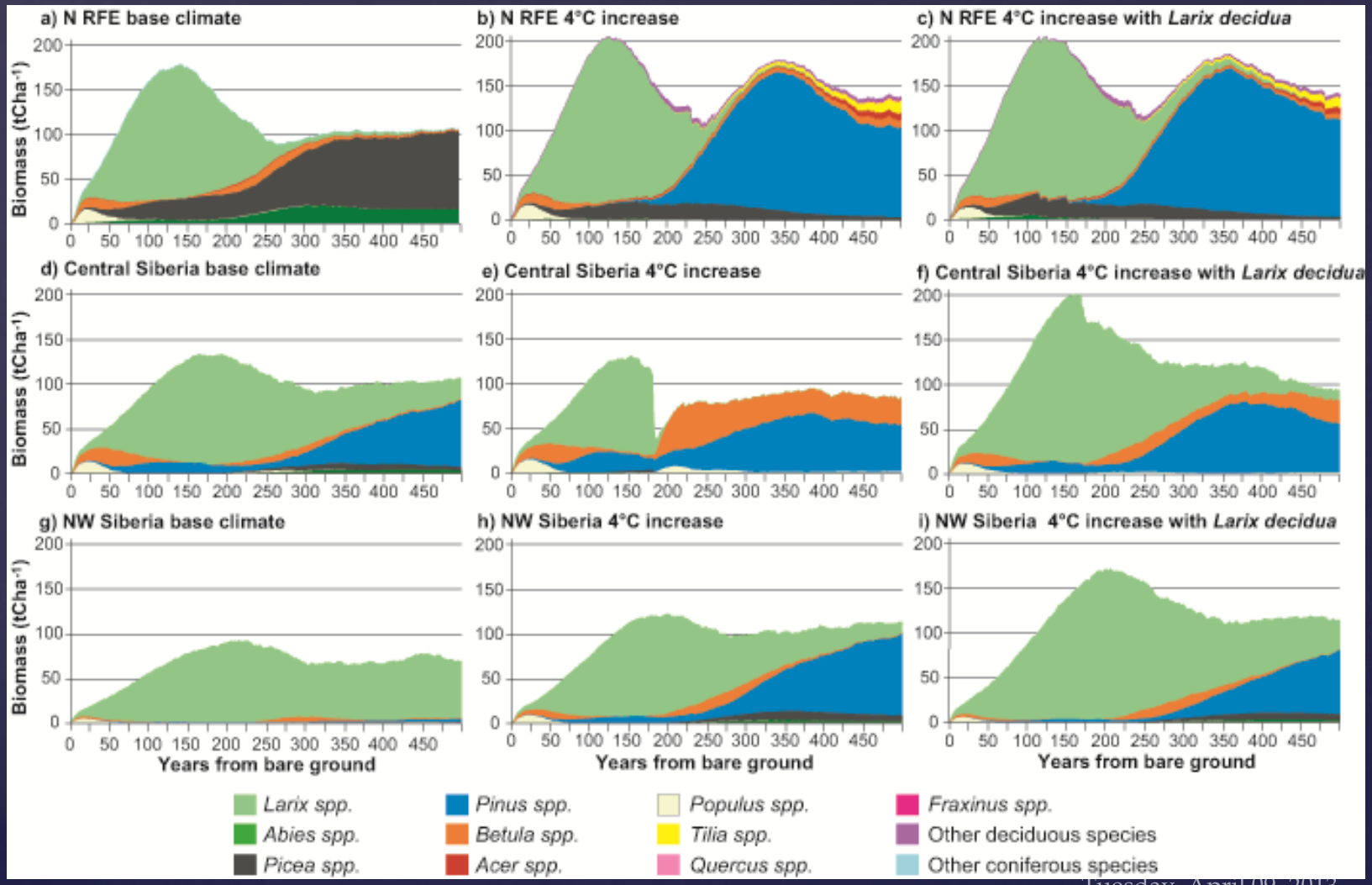
NELDA sites validation: Overall accuracy – 63.8%



Synthesis Output 3: Regional Forest & Climate Change Scenarios



Objective 3: Regional Climate and Climate Change Scenarios

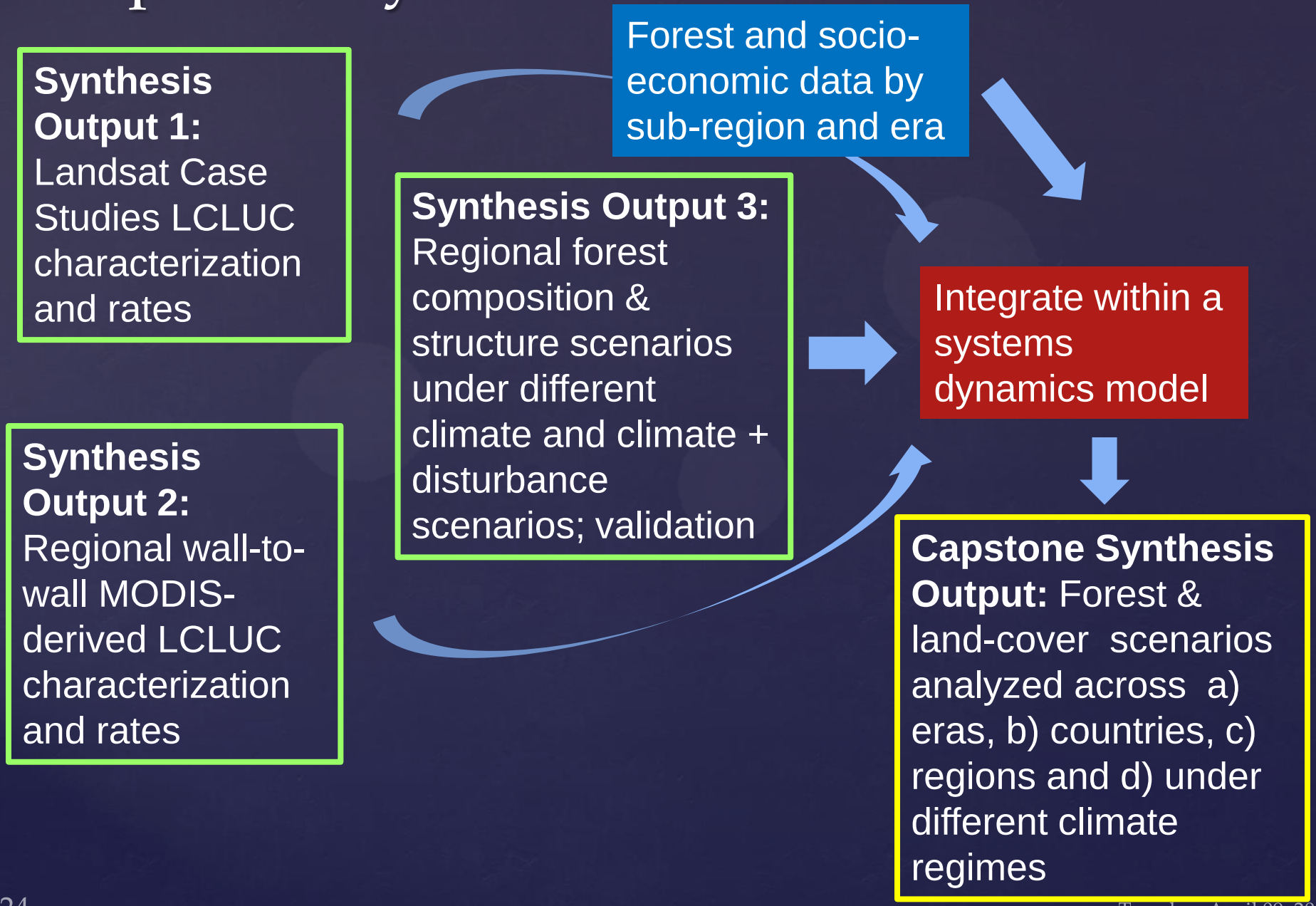


Carbon : Forest gap model outputs and Landsat-based LCLUC

	Tomsk		Krasnoyarsk		Irkutsk	
LCLUC	Area (%)	Area-weighted Δbiomass	Area (%)	Area-weighted Δbiomass	Area (%)	Area-weighted Δbiomass
Forest disturbance	4.82	-3.45	11.37	-4.98	3.98	-3.59
Forest regrowth	15.25	+6.46	20.91	+11.35	9.00	+3.11
Total		**+3.01**		**+6.37**		**-0.48**
Constant	75.35	–	60.75	–	74.26	–
Unknown	4.52	-0.34	6.97	+0.34	12.76	-1.87

- The total is the sum of Δbiomass between post-Soviet years 1990 and 2000 (Modified from Zhao, Bergen & Shugart 2009).
- Disturbance and regrowth from Landsat analysis
- Biomass/carbon from FAREAST model

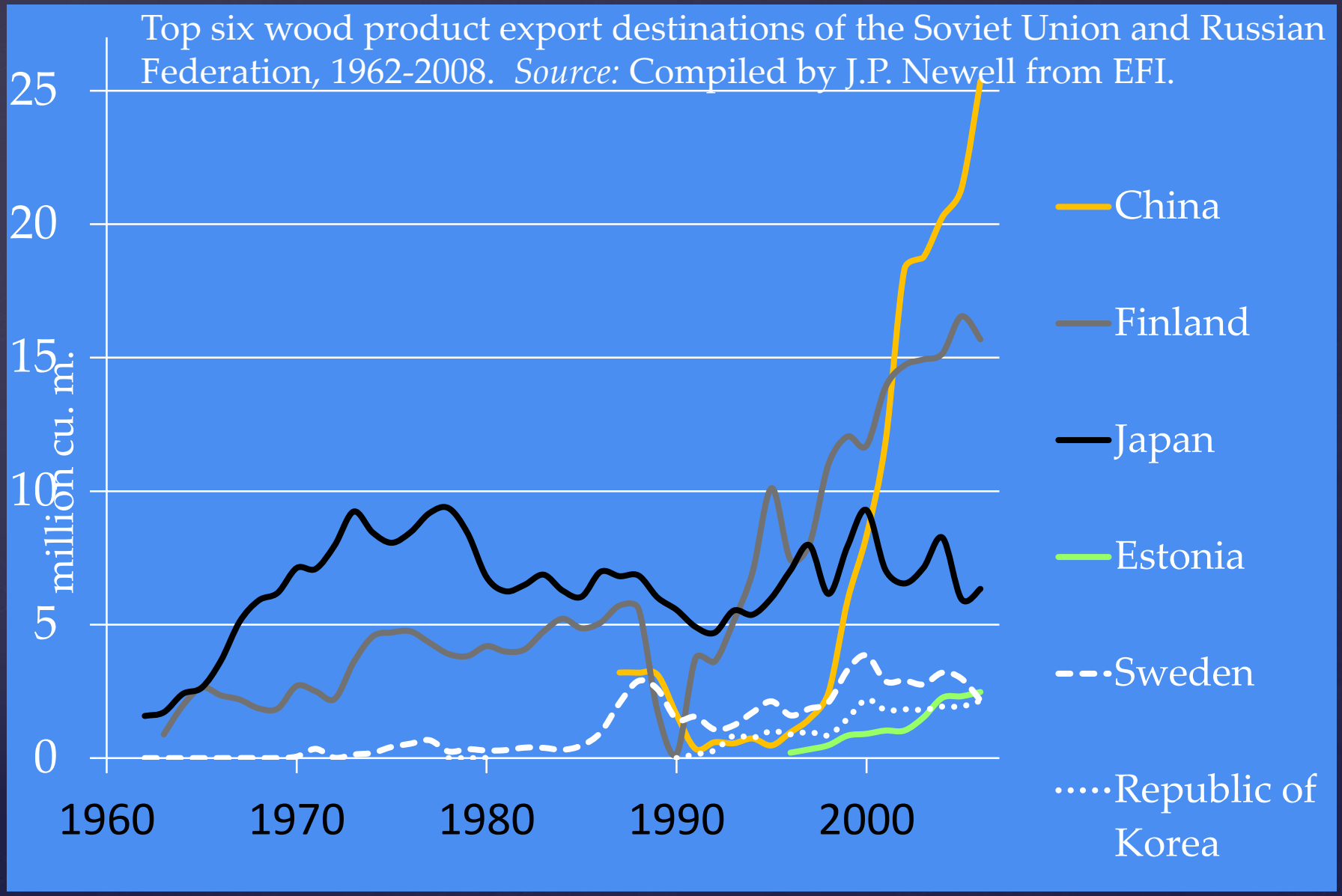
Capstone Synthesis



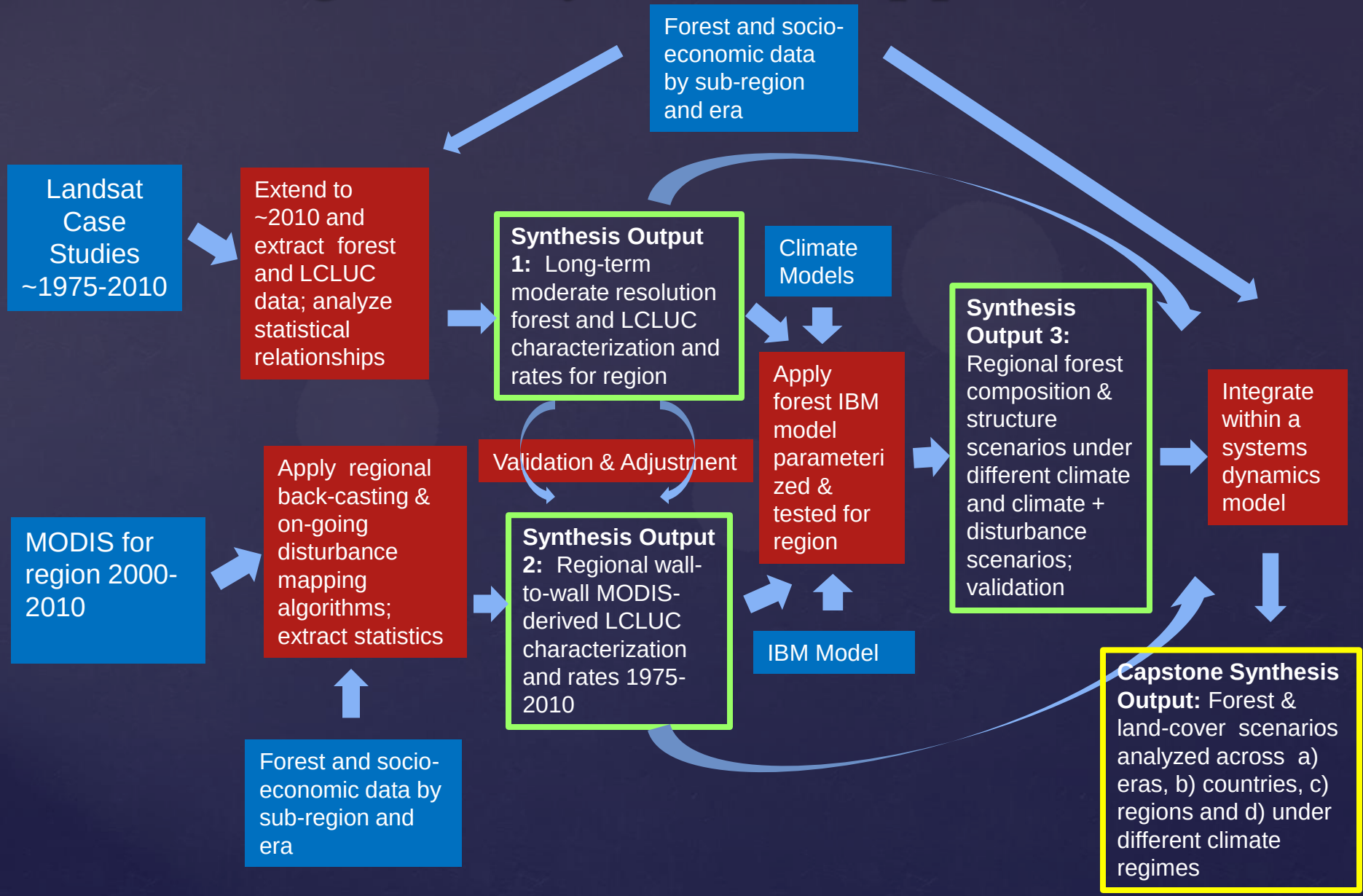
Capstone Challenges

- Potential model types –
  - what answers our objectives?
  - what is feasible?
- Proposed a systems dynamics model
  - An aspatial model type
  - Quantify stocks and flows
  - Incorporate external considerations
    - e.g. external markets
- Refine proposed approach as needed

Changing External Exports



Integrated Synthesis Approach



Some thoughts on LCLUC Synthesis Requirements…..

- Identify important region/s WRT LCLUC
- Acquire very sound understanding of the key socio-economics and land-cover/land-use issues of the region or system under study
- Have a significant body of relevant previous and ongoing remote sensing-based research
- Have significant applicable methodologies to bring to synthesis
- Develop an ‘a priori’ integrative approach to synthesis

THANK YOU

Acknowledgments

- NASA LCLUC program
- Garik, Pasha, Chris
- Our team members
- Our Russian colleagues
- Our students